DOCUMENT RESUME

ED 359 924 IR 016 139

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TITLE Gender and Software Effects in Computer-Based Problem Solving.
PUB DATE Mar 93
NOTE 8p.; Paper presented at the Annual Meeting of the Society for Research in Child Development (New Orleans, LA, March 25-28, 1993).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Ability; *Computer Assisted Instruction; Computer Games; Computer Software; Females; Foreign Countries; Junior High Schools; Junior High School Students; Males; Performance; *Problem Solving; *Sex Differences; Sex Stereotypes
IDENTIFIERS England

ABSTRACT

Whether gender differences in performance using computer software are due to sex stereotyping or gender differentiation in the programs was investigated in two studies. An adventure game, "King and Crown," with all male characters, and a gender neutral game, "Honeybears," were played by 26 female and 26 male 11- and 12-year-olds in Milton Keynes (United Kingdom). Both games were essentially route-planning tasks with similar features. In a second study, a new version of "King and Crown," called "Pirates," was compared to "Honeybears" in a study with 24 female and 24 male 11- and 12-year-olds in Milton Keynes. Considered together, results of these studies provide a clear illustration of the way characteristics of the software can exert an effect on the performance of girls. While the performance of boys was relatively unaffected by the software, that of girls was far superior when playing "Honeybears." Further studies will examine the expressed preferences of boys and girls for the two games. (SLD)

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Gender and Software Effects in Computer-Based Problem Solving.

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Poster presented at the Society for Research in Child Development Convention, New Orleans, Louisiana, March 25th - 28th, 1993.

Introduction.

There is currently concern among educationalists that the increasing use of computers in schools could place girls at a disadvantage. If girls are less interested in and spend less time using computers than boys, then it is likely that they will obtain fewer of the benefits resulting from their use. There are already some indications in the literature that there are substantial gender differences in both attitudes towards computers and patterns of computer use. There are also some reports of girls performing significantly less well on computer-based learning tasks than boys. Recent work by Barbieri and Light (1992), for example, found girls to be much less successful than boys at solving a computer-based route planning task known as the 'King and Crown'. Subsequent work by Littleton, Light, Joiner, Messer and Barnes (1992), however, suggests that girls' performance on this type of computer task may be crucially influenced by superficial characteristics of the software in use. Littleton *et al* examined the relative performance of boys and girls using a structurally isomorphic but less gender-stereotyped version of the 'King and Crown' task known as 'Honeybears'. Whilst the 'King and Crown' employed all male characters and a masculine stereotyped 'quest' scenario, the 'Honeybears' version involved gender-neutral characters (teddy-bears) within a fairy-tale scenario. The results of this study revealed that the previously observed gender difference in performance had been substantially ameliorated. Whilst the boys enjoyed some advantage throughout their period of work on the computer they did not improve their performance any more than the girls did. The obvious factor to consider in explaining this attenuation of the gender difference is the change in software. Given that the structure and the cognitive demands of the two tasks were essentially identical, the reduced gender differentiation shown with 'Honeybears' suggests that the imaginary setting of the task and the gender of the represented characters may have had a substantial bearing on the relative performance of boys and girls. There were, however, other design differences between the Barbieri & Light study and that conducted by Littleton *et al* which preclude us from drawing this conclusion unambiguously. In light of this we undertook a controlled comparison of the performance of girls and boys using both types of software. It is this comparison which is detailed here. Before

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providing more information concerning the design and procedure employed in this study it is worth spending a little time considering the nature of the tasks in more detail.

The Tasks.

The adventure game format of the task was adopted as a result of evidence (Crook, 1986) which suggested that this type of software is particularly effective at stimulating rich discussion between children. Essentially, the 'King and Crown' constitutes a route planning task. Whilst the underlying problem is fairly simple, the task as a whole is quite complex, as successful completion requires the child to search for relevant information, plan a solution and react constructively to any obstacles encountered along the way. Implemented in Hypercard on the Macintosh computer and couched in an adventure game format, the scenario is a quest involving the retrieval of a crown from an island. The children are told that:- "The King lives in his castle in Ashlan. He wants his crown and all his subjects (the driver, the pilot and the captain) in Ashlan for a feast. He wants you to give the orders to get them all there."

The task as it is presented to the subjects consists of a screen map on which there are a number of 'LOCATION' buttons marked by rectangles (see Figure 1). When the mouse-driven cursor is positioned over and then clicked on one of these buttons, the children gain access to a location screen. This screen contains numerous buttons which enable the children to access information concerning the objects, persons, and means of transport present at a particular location. The children can also gather information by using the 'INFO' button. Clicking on this button produces a general information screen which provides the children with another means of requesting information. If, for example, they clicked on the box marked 'Pilot' they would access a screen from which they could request general information about the Pilot and/or discover his whereabouts.

The 'GOAL' button makes available a written statement of the goal or the aim of the game, whilst the 'KEY' button makes available a key which indicates the significance of the various route markings. It is through the process of information searching that the children can discover the initial disposition of the characters, the crown and the different pieces of transport: the three characters are all initially at Ashlan, along with a car. There is a ship at Brockley, another at Crowmarket and there is a plane on the island of Hushley. The crown is on the island of Fruggle.

When the children have (or think they have) sufficient information, they can initiate a move by clicking on the 'ACT' button - a procedure which accesses the 'move' screen. The children are then required to specify the point of departure, the destination, the characters being moved (and whether or not they are moving the crown) and the piece of transport being used. Having specified the

details of a given move in this way, the move is then executed by clicking on 'GO'.

Note that Pirates will steal the crown from any ship sailing the sea. This militates against the otherwise obvious route from Ashlan via Brockley to Fruggle and back. The optimal solution is to take the car (and driver, captain and pilot) to Crowmarket, to take the ship (and captain and pilot) to Hushley, to take the plane (and the pilot and the captain) to Fruggle to collect the crown and then return to Crowmarket, and then for all to return by car to Ashlan: a total of five moves in all.

The software automatically updates all relevant information as each move is made, thus at any point the children can stop and take stock of where the characters, transport etc. are. Whilst in theory this might not be necessary, in practice it usually is. Most children, at least initially, either set off in the wrong direction or take the wrong characters and thus encounter difficulties. If the children attempt to make a move which is impossible, or which would lead to the Pirates stealing the crown, they get a message to this effect, and they are prevented from actually making the move. This means that the children then have to re-plan the move, to take account of the particular problem they have encountered. The task is thus a difficult one - nevertheless most children find it engaging and highly motivating.

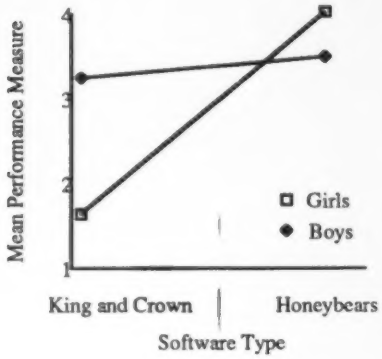
The 'Honeybears' version of the task (see Figure 2) draws on ideas from the popular nursery song 'The Teddy Bears Picnic' and a television advertisement involving a Honeymonster. The basic scenario is that three bears have set out for a picnic at Almwood, and discover that they have forgotten their honey. The honey is on an island at the other side of the river, but in the river there are Honeymonsters who will steal the honey if the bears attempt to move it by boat: this in turn necessitates the retrieval of the honey by balloon. Thus, whilst the 'Honeybears' and the 'King and Crown' tasks differ with respect to the context in which the problem is set (and also with respect to certain minor interface characteristics), both in fact present the same problem in the same adventure game format and call for an identical solution strategy.

Study 1.

In this study we directly compared the performance of boys and girls on the two types of software, under identical conditions. The subjects were fifty-two 11-12 year-olds who were taken from two parallel classes in a junior school in Milton Keynes, U.K. The sample included 26 girls and 26 boys. Within this sample each child was randomly assigned to work on one of the two different software types. Thus the numbers of children in each condition were as follows:- (1) 'King and Crown' (13 girls and 13 boys) and (2) 'Honeybears' (13 girls and 13 boys). The two experimenters (one male and one female) took groups of four children (2 girls and 2 boys) to a quiet classroom in the school. The

children were then seated in boy-girl pairs at two of the four Macintosh SE computers that had been positioned around the periphery of the classroom (note that the orientation of each machine ensured that its screen was visible only to its particular user/s and that each computer was controlled by mouse only, no keyboard being used). One of the pairs was then introduced to the 'King and Crown' software, whilst the other was introduced to the 'Honeybears' software. In both cases the children were shown the goal or the aim of the task and they were shown how to retrieve the information available in the software. They were also shown how to execute a move, and the consequences of attempting to make an impossible move. Finally, the children were informed of the time available (30 minutes) and told not to worry if they did not complete the task. Having been introduced to a task each child was then positioned at their own computer and the experimenters sat apart leaving each individual child to work alone on the relevant problem. Each child's performance on the task was then measured on a 0-8 scale. This scale indexes the degree of progress towards task solution: 0 corresponds to no move, whilst 8 corresponds to successful completion of the task in less than 10 minutes or less than 10 moves. The results are shown opposite.

A 2-way between subjects analysis of variance reveals that there is a significant main effect of software type ($p < 0.05$), with the mean level of performance being higher for 'Honeybears' ($x = 3.81$) than for the 'King and Crown' software ($x = 2.5$); that whilst the mean performance



level of the boys is slightly higher than that of the girls, there is no significant main effect of gender, and that there is a significant software x gender interaction ($p < 0.05$). The performance of the boys remains virtually unaffected by the software type, whereas the performance of the girls is far superior when using the 'Honeybears' software. Interestingly, the girls' mean level of performance on 'Honeybears' exceeds that of the boys, although this difference is not in itself statistically significant.

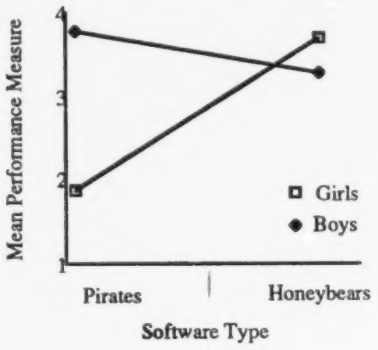
When we changed from the 'King and Crown' to 'Honeybears' it was not with this direct comparison study in mind and we had taken the opportunity to 'improve' certain aspects of the interface. If one looks at the map for the 'King and Crown' task and the map for the 'Honeybears' task one can see a clear example of some of the differences in the interface characteristics of the two software types. This led us to question how the children would respond if the interfaces of the 'King and Crown' and

the 'Honeybears' software were as closely matched as possible given the constraints of the different scenarios. Study 2 was conducted to investigate this issue, as well as to allow a test of the robustness and replicability of the effects observed.

Study 2.

For this study a new version of the 'King and Crown' was designed. Called the 'Pirates', the interface of this software was designed to be analogous to the interface of the 'Honeybears' software within the constraints imposed by the different storylines (see Figure 3). What this study does, then, is directly compare the performance of boys and girls on the 'Honeybears' and the 'Pirates' software. The subjects were forty-eight 11-12 year-olds who were taken from two parallel classes in a junior school in Milton Keynes. The sample included 24 girls and 24 boys. Within this sample each child was randomly assigned to work on one of the two different software types. The numbers of children in each condition were thus as follows:- (1) 'Pirates' (12 girls and 12 boys) and (2) 'Honeybears' (12 girls and 12 boys). Both the experimental method and performance measurement were identical to that described previously. The results are shown opposite.

A 2-way between subjects analysis of variance reveals that whilst the mean level of performance is higher for the 'Honeybears' (x = 3.38) than for the 'Pirates' software (x = 2.71), there is no significant main effect of software type. Furthermore, whilst the mean performance level of the boys is higher than that of the girls, there is no significant main effect of gender.



The software x gender interaction just fails to reach conventional levels of statistical significance (p = 0.08). As in the previous study, the performance of the boys remains relatively unaffected by the software type, whereas the performance of the girls is far superior when using the 'Honeybears', as opposed to the 'Pirates', software. Moreover, as in the previous study, we see that the girls' mean level of performance on 'Honeybears' exceeds that of the boys, although this difference is not statistically significant. So despite the failure of the gender x software interaction term to quite reach the 5% level (which may reflect the lower N's as much as anything else) these results would seem to suggest that it is the differences in the scenario, as opposed to characteristics of the interface which are accounting for these effects.

Considered together, the results of these studies provide a clear illustration of

how logically 'incidental' characteristics of problem solving software, such as the task scenario, can exert a striking and dramatic effect on girls' task performance. This in turn alerts us to the importance of bearing such factors in mind when designing computer tasks of this type. In terms of an explanation for our findings, from watching the children working on the different tasks, we suspect that our results reflect the children's relative levels of 'engagement' with the tasks. That is to say, whilst the boys seemed to find both software types equally appealing the girls appeared to find the 'King and Crown' software less enjoyable and less motivating than the 'Honeybears' version and this in turn may have accounted for (or contributed to) their poorer task performance when using this software. If it is the case that the girls find the 'King and Crown' software less enjoyable than the 'Honeybears', one might expect this to be reflected in their expressed opinion of the software. That is to say, when asked to rate how much they enjoyed playing the games, one might expect the girls who played the 'Honeybears' to respond more positively than the girls who played the 'King and Crown'. We are currently analysing data which will enable us to make this comparison.

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(1) Barbieri, M. S. & Light, P. (1992) Interaction, gender and performance on a computer-based problem solving task. *Learning and Instruction,* 2, 199-214.

(2) Littleton, K., Light, P., Joiner, R., Messer, D. and Barnes, P. (1992) 'Pairing and gender effects on children's computer-based learning.' *European Journal of Psychology of Education,* 311-324.

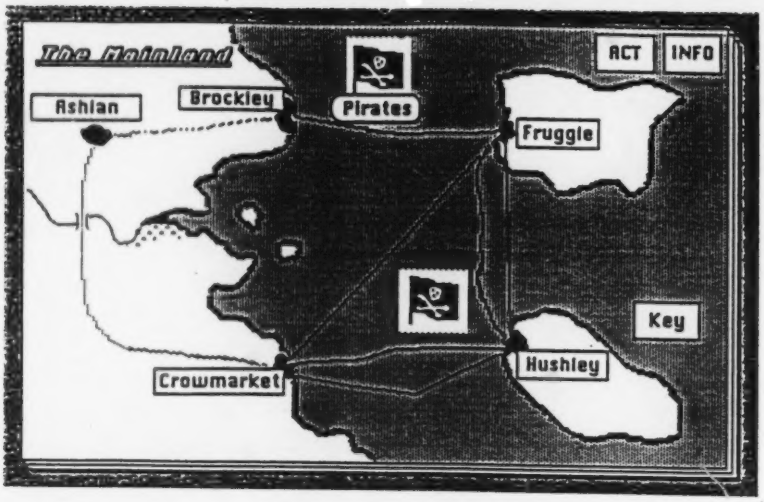

Figure 1: The 'King and Crown' Map.

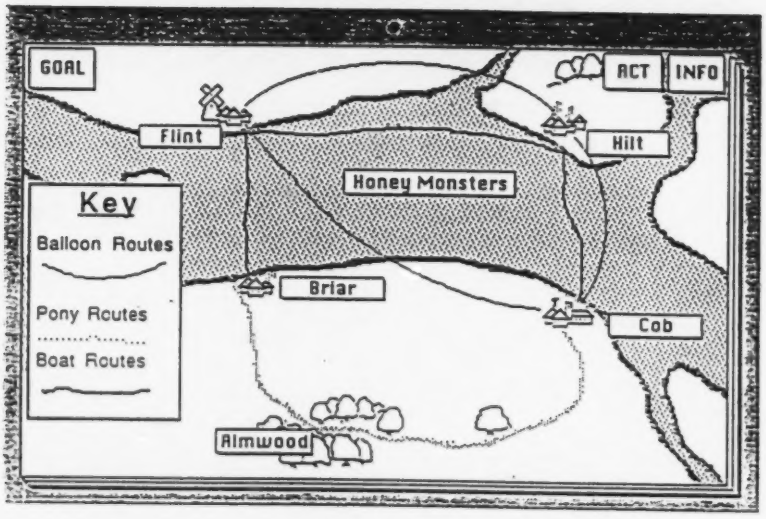

Figure 2: The 'Honeybears' Map.

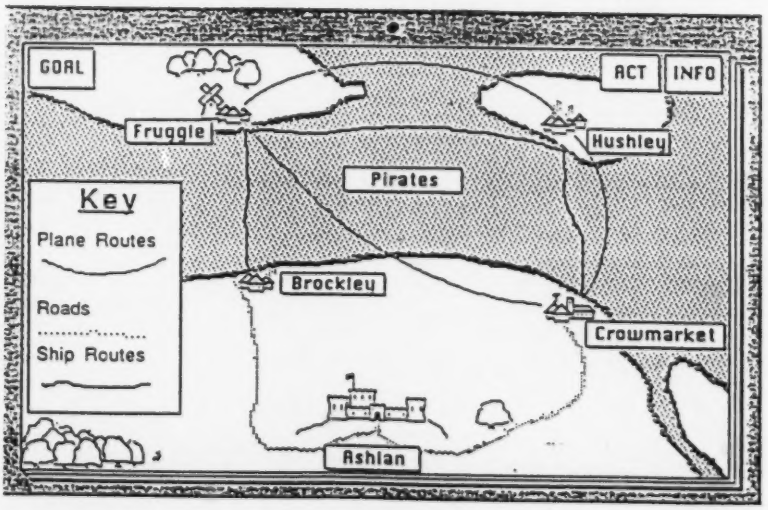

Figure 3: The 'Pirates' Map.

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